At the time of issue this report has not been published. Any author desiring to quote this paper should refer to it as "A paper of the Meteorological Research Committee (London).
M.R.P. No. 889 by Dr. F. J. Scrase
A copy is available in the Library of the Meteorological Office."

M.R.P. 889
S.C.I/95
S.C.II/180
19th November, 1954.

AIR MINISTRY

METEOROLOGICAL RESEARCH COMMITTEE

THE APPLICATION OF RADIATION AND LAG CORRECTIONS TO RADIO SONDE TEMPERATURES

by

F.J. Scrase (Meteorological Office)

Introduction

The radiation error of a radio sonde at any particular height and solar altitude depends on the absorption factors of the temperature element and its shield, on the albedo of the reflecting surface below the sonde, on the rate of ascent and on the swinging of the sonde on its suspension. Some values of the errors for the M.O. radio sonde at various heights and solar altitudes are given in Table I, which is an expanded version of Table Vd of M.R.P. 836. These values are calculated for the following conditions:

Absorption factor of element for short waves	0.67
" " " " long waves	0.18
" " shield for short waves	0.33
" " " " long waves	0.03
Albedo	0.35
Rate of ascent	6 m/sec
Maximum angle of swing	30°

Comparisons of calculated and observed radiation effects indicate that the values given in Table I are probably accurate to within 7 per cent.

We have to decide to what extent we should attempt to allow for variations in the above conditions. So long as the materials and finish of the element and shield remain unchanged their absorption factors will not differ much from the values quoted above. Variations in the swinging of the sonde would be difficult to take into account but on most occasions the assumption of a 30° angle of swing would be good enough for practical purposes.

Effect of albedo

The albedo of 0.35 is probably the best all-round value for earth surfaces with some cloud cover. Albedos for cloud appear to vary between 0.4 and 0.75, for snow and ice between 0.45 and 0.85 and for water between 0.05 and 0.45. Values ranging from 0.1 to 0.6 are, therefore, likely to be encountered in some situations. For these limits the values of the radiation errors of Table I would have to be multiplied by the following factors at all heights:

Solar altitude	10°	30°	50°	70°	90°
Albedo 0.1	0.98	0.87	0.84	0.80	0.82
Albedo 0.6	1.07	1.15	1.17	1.20	1.19

Thus, except at low solar altitudes, a change of 0.1 in the albedo alters the radiation error by about 7 per cent. In view of the difficulty which radio sonde stations would have in estimating the albedo it seems inadvisable to attempt to allow for variations from the value assumed for average conditions.

/Effect

Effect of rate of ascent

The rate of ascent of 6 m/sec (1200 ft./min.) used for Table I is about the average between 1000-400mb. but there is usually a systematic increase up to the tropopause and a decrease above that level. The change with height is roughly as follows:

Height, Km.	0	3.0	6.3	9.2	11.8	16.2	>18
mb.	1000	700	450	300	200	100	<70
Rel. rate of ascent	1.0	1.0	1.05	1.15	1.15	1.02	1.0

It would therefore be appropriate to modify Table I to take account of these systematic changes, bearing in mind that the radiation error varies inversely as the square root of the rate of ascent, except in the lower levels where the errors are, in any case, small.

The variations in rate of ascent from one sounding to another have a standard deviation of about 7 per cent. Most of these variations would, therefore, be within 20 per cent. of the average and the corresponding radiation errors within 10 per cent.

If an accuracy of 0.25°C. is aimed at, account should be taken of any large difference in the rate of ascent from normal at levels above 200 mb. with high solar altitudes and above 40 mb. with low solar altitudes. The corrections would be obtained by multiplying those given for the standard rate of ascent by the square root of the ratio of the standard rate to the actual rate.

Solar altitude

For corrections at the higher levels it is desirable to know the solar altitude to the nearest 5°. This could be obtained from Fig. 28 of the Observer's Handbook if the diagrams were extended to cover higher solar altitudes. Suitable diagrams are included in the U.S.W.B. Manual of Radio sonde Observations, Circular P. The time used for obtaining the solar altitude should be that at which the sonde reaches 200 mb. i.e. about 30 min. after the time of release.

Lag corrections

As the lag error depends directly on the lag coefficient and the rate of change of temperature of the thermometer element, the most accurate way of correcting for this error is to evaluate it from the appropriate lag coefficient and the rate of change shown on the temperature (frequency)/time graphs plotted for routine soundings. However, it should generally suffice to adopt a simpler procedure by assuming a constant lapse rate of, say, 6°C/Km in the troposphere and isothermal conditions in the stratosphere.

On this basis, and using the lag coefficients for a rate of ascent of 6 m/sec given in Table VI of M.R.P. 836, the corrections to be applied, to night as well as to day measurements, are those given in Table III. They have not been adjusted for the systematic change in rate of ascent with height since this would make no significant difference.

For the isothermal stratosphere no lag corrections are necessary at night but by day at high levels they are necessary because of the rapid change of radio sonde temperature with radiation absorption and rapidly diminishing convective heat loss. These corrections are worked out in Table II, using the rate of change of radiation error with height given in M.R.P. 836. They can, of course, be combined with the radiation corrections of Table I into a single table. It will be noted that they are hardly significant at levels below 50 mb. and they do not vary much with solar altitude.

Lapse rates differing by more than 1°C/Km from the assumed values would not alter the lag corrections by more than 0.25°C. except at levels above 40 mb.

/Recommendation

Recommendation

It is suggested that for routine reports of radio sonde temperatures Tables I and II should be combined to provide radiation corrections for day time soundings and Table III should be used to correct for lag errors in day and night soundings in the troposphere.

TABLE I

Radiation Corrections

mb.	Ht. (ICAN)	Solar Elevation 0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
		°C (To be subtracted)									
10	30.9	10.0	12.3	14.8	17.7	19.4	20.4	19.7	19.4	20.4	21.3
20	26.3	4.9	6.3	7.6	9.1	10.2	10.8	10.7	11.1	11.8	12.3
30	23.8	3.3	4.3	5.3	6.7	7.6	8.0	8.0	8.2	8.9	9.4
40	22.0	2.5	3.3	4.1	5.3	6.1	6.5	6.5	6.7	7.3	7.8
50	20.6	1.9	2.7	3.4	4.4	5.2	5.5	5.5	5.7	6.2	6.6
60	19.4	1.5	2.2	2.9	3.6	4.5	4.7	4.8	5.0	5.4	5.8
70	18.4	1.3	1.9	2.5	3.1	3.9	4.1	4.2	4.5	4.9	5.1
80	17.6	1.1	1.7	2.2	2.8	3.6	3.8	3.9	4.1	4.5	4.6
90	16.8	1.0	1.5	2.0	2.5	3.2	3.4	3.5	3.8	4.1	4.3
100	16.2	0.9	1.4	1.8	2.3	2.9	3.2	3.3	3.5	3.8	4.0
110	15.6	0.8	1.2	1.6	2.1	2.7	2.9	3.0	3.3	3.6	3.8
130	14.5	0.6	1.0	1.4	1.8	2.4	2.5	2.7	2.9	3.2	3.4
150	13.6	0.6	0.9	1.2	1.6	2.1	2.2	2.3	2.6	2.9	3.1
170	12.8	0.5	0.8	1.1	1.5	1.9	2.1	2.2	2.4	2.7	2.8
200	11.8	0.4	0.7	0.9	1.3	1.7	1.9	2.0	2.2	2.4	2.6
250	10.4	0.3	0.6	0.8	1.1	1.5	1.7	1.7	1.9	2.1	2.3
300	9.2	0.3	0.5	0.7	1.0	1.4	1.6	1.5	1.7	1.9	2.0
350	8.1	0.2	0.4	0.6	0.9	1.2	1.4	1.3	1.5	1.7	1.8
400	7.2	0.2	0.4	0.5	0.9	1.1	1.3	1.2	1.4	1.5	1.7
450	6.3	0.2	0.3	0.5	0.8	1.0	1.2	1.1	1.3	1.4	1.6
500	5.6	0.1	0.3	0.4	0.7	0.9	1.1	1.0	1.3	1.4	1.5
550	4.9	0.1	0.3	0.4	0.7	0.9	1.1	1.0	1.2	1.3	1.4
600	4.2	0.1	0.3	0.4	0.6	0.8	1.0	0.9	1.1	1.2	1.3
650	3.6	0.1	0.2	0.3	0.6	0.8	1.0	0.9	1.1	1.1	1.2
700	3.0	0.1	0.2	0.3	0.6	0.7	1.0	0.9	1.0	1.1	1.2
750	2.5	0.0	0.2	0.3	0.5	0.7	0.9	0.8	1.0	1.0	1.1
800	1.9	0.0	0.2	0.3	0.5	0.7	0.9	0.8	0.9	1.0	1.1
850	1.5	0.0	0.1	0.3	0.5	0.7	0.8	0.8	0.9	0.9	1.0
900	1.0	0.0	0.1	0.2	0.4	0.6	0.8	0.7	0.8	0.9	1.0
950	0.5	0.0	0.1	0.2	0.4	0.6	0.7	0.7	0.8	0.8	0.9
1000	0.1	0.0	0.1	0.2	0.4	0.6	0.7	0.7	0.7	0.8	0.9

TABLE II

Lag corrections to radiation corrections

0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	Mean
°C (To be added)										
1.0	1.2	1.5	1.8	2.0	2.1	1.8	1.5	1.5	1.7	1.6
0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE III

Lag corrections for 6°C/Km

Subtract for lapse
3.9
2.3
1.7
1.5
1.3
1.1
1.0
0.9
0.9
0.8
0.8
0.7
0.6
0.6
0.5
0.5
0.4
0.4
0.4
0.3
0.3
0.3
0.3
0.3
0.3
0.3
0.3
0.3
0.3
0.3
0.3